CHEMICAL-VEGETATIVE STABILIZATION

of an

ABANDONED CHROMITE TAILINGS POND

Presented to the

MINERALS WASTE STABLIZATION LIAISON COMMITTEE

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by

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The Stillwater District of south-central Montana is well known in geology and mining circles for its large concentrations of several important minerals. It is claimed to have the largest known reserves of copper-nickel sulfides in the United States, the largest reserves of platinum and iron sulfides in North America , and the largest reserves of chromite in the Western Hemisphere. Although tonnages of these reserves are quite large, the ores themselves are of moderate to low grades and mining activity has been limited to only a few intermittant small scale operations. The most significant mineral production has been from the chromite ores, but only in times of national emergencies such as World War I, World War II and the Korean conflict. The largest single period of chromite activity was from 1952 through 1961 when the American Chrome Company, under contract with the United States Government, produced more than 930,000 tons of 38% chromite concentrates through a 1000 ton per day gravity concentrator.

The tailings from this concentrator were impounded in a 35 acre pond system. The decanted transport waters were then discharged directly into the Stillwater River, one of Montana's prime fishing and recreational streams.

Upon completion of the contract American Chrome ceased operations in the area. In the mid 1960's the Anaconda Company initiated geological exploration activities on the copper-nickel ores in the Stillwater District and acquired a majority interest in the American Chrome properties which included the tailings pond.

Wind borne dust from the tailings pond was a problem to American Chrome. Some attempts were made to reduce the fugitive dust problem including the use of snow fencing and some experimental surfacing with asphalt. These attempts were unsuccessful and within 10 years after abandonment the bulk of the tailings were excavated and deposited elsewhere by the wind.

In 1971,The Anaconda Company made plans to stabilize the tailings pond to prevent wind erosion. Before discussing the stabilization project, however, a little background information on topography and climate is necessary.

The Mouat Tailings Pond, so called in honor of the man who originally located and mined the chromite ore in the area, is situated in the mouth of the Stillwater River Canyon, some seventy five miles south west of Billings, Montana. At this point, the Canyon is deep and narrow. Elevation at the pond is 4900 feet above sea level, but promptly rises to 8500 ft. within 2 miles on either side. Immediately to the south and west rise the Beartooth Mountains containing Montana's highest point, 12,799 ft. Granite Peak. To the north and east are the Great Plains stretching to the Mississippi River.

Temperatures range from 40° below 0 in the winter to as much as 100° above during the summer. Recorded highs and lows from June thru December 1972 at the tailings pond were 94° at the end of July and -20° during the 2nd week of December. Average annual precipitation is approximately 20". The bulk of the precipitation comes as late winter snows. Soft rains occur in June while intense, short duration precipitation results from late July and August thunderstorms.

The natural vegetation of the area is typical of cool season arid areas. (Appendix I). The most significant natural factor affecting the outcome of any stabilization effort, and the source of our problem is wind. The local people claim that the wind blows in excess of 100 MPH during the late fall and winter months. It is often officially recorded at those speeds at Livingston, Montana, 40 miles away in a similar topographical setting. A recorder set up on the tailings pond in June of 1972 provided the following information:

Highest Daily Average Speed	December 26	33.6 MPH
Highest Hourly Average Speed	December 13	46 MPH
Highest Average Speed for a 2-week period	December 1-15	19.5 MPH

The lowest daily average was January 8, 1973 with a speed of .97 MPH while the lowest two week average was 6.4 MPH during the first two weeks of September, 1972. (Appendix II).

In June of 1971, samples of the tailings were taken, including sand from the dikes which appeared to be undisturbed since its deposition, slimes, and sand from a dune that was created from ten years of blowing. These samples were placed in pots in the following arrangements: dune sand, dike sand, slimes, dike sand mixed 50% with slimes, and dike sand stratified with slimes to simulate the natural deposition of the tailings material. A second set of pots containing the same tailings mixtures except the stratified mixture was prepared and fertilized with the equivalent of approximately 400 pounds per acre of 16-20-0 fertilizer. All pots were seeded with a lawn grass seed mixture, placed under a 150 watt incandescent light providing a 24 hour photo period, placed under clear plastic and watered as needed for two weeks. Maximum germination occurred during this time, and six weeks after seeding, all pots were moved outside. Irrigation was by intermittant lawn sprinkling and normal precipitation. Furthermore, the pots were subjected to the ravages of children and dogs playing around and through them.

The purpose of this test was to determine if the tailings could support vegetation. By September of 1971, the grasses had matured and indicated that the tailings material would support vegetation with no special treatments.

The wind over the years had excavated the tailings pond to such an extent that it was impossible to drive equipment over the rough surface of the remaining tailings. The tailings material was "benched" as much as 4 feet in places, and in the upwind corners of the dikes, there was as much as 30 feet of elevation at difference at close to 2:1 slopes. Furthermore, only exceptionally wide tracked, low-weight displacement machines could negotiate the soft slime benches which comprise significant portions of the surface area. As a result of these conditions, hydroseeding, employing the use of dust-stabilizing chemicals, was chosen as the most practical approach to revegetation.

The Anaconda Company committed itself publically to commence stabilization of the tailings pond during the fall of 1971, and plans were made to set up an experimental design to test several dust stabilizing chemicals and wood-fiber mulches for effectiveness and cost prior to attempting total, permanent stabilization. The test was postponed to the spring of 1972 in heed of warnings from local people about the severe winter winds. Instead, seven rows of 4 foot high snow fences, 200 feet in length were erected for temporary control of the wind blown tailings. Fortunately, the right decision was made. A severe windstorm hit the area December 9, 1971, with gusts recorded as high as 105 MPH at Livingston, Montana. All that remained of our snow fences were a few scattered sections not exceeding 10 feet in length.

Early in the spring of 1972, 23 one acre plots were staked on the pond surface. Hydroseeding with stabilization chemicals, wood fiber mulch and a seed mixture commenced on May 15 in order to take advantage of the normal June rains. Treatments included Coherex, Soil Seal, Huels Soil Stabilizer 801, Kelzan and Kelgum as stabilizing chemicals, and Conwed and Weyherhaeuser wood fiber mulches. An additional 5800 square feet each of Conwed and American Excelsior Soil Retention Blankets were used. (Appendix III). Where quantities allowed, replicates of each treatment were made to provide more accurate conclusions. (map).

It was hoped that the vegetation would have developed sufficiently by the end of September to be able to survive the severe late fall and winter winds.

All materials tested were supplied in part or entirety by the manufacturers, and in some cases, manufacturer's representatives were present during the application. (Appendix VIII).

Each plot received the equivalent of 20 pounds of seed per acre. (Appendix IV). The U.S. Soil Conservation Service was consulted on the advisability of the project and for recommendations of vegetative species which would be adapted to the severe conditions existing on the site. They gave additional assistance by providing a portion of the Indian ricegrass as well as all of prairie sandreed and Mammouth Wildrye seed used in the project. This material came from the SCS Plant Materials Center near Bridger, Montana a short distance away.

Hydroseeding was performed by a contractor doing a job nearby for the Montana Highway Department. His equipment included a 3000 gallon capacity hydroseeder plus accessory equipment. Access for the hydroseeder was limited to the top of the dikes, necessitating the bulk of the work be done by hose, in some cases, up to 600 feet in length. Hydroseeding took an average of 2.3 hours per acre, not including breakdowns or inclement weather. The quantity of chemical, fiber mulch and water required two loads per one acre plot.

250 pounds of 26-26-0 fertilizer was applied by hand operated broadcast seeders during the first week of September.

Sporadic germination occurred until August, and then increased through the third week of September when temperatures fell to 18°. Unfortunately, those plants which germinated were not able to develop sufficiently to withstand the early onslaughts of winter.

A series of 40 1/10,000 acre examination plots were made on each one-acre test plot during the second week of September to determine the distribution and denisty of germinated seedlings. No attempt was made to identify the plants beyond grass or legume, and this distinction was not made in the final analysis. Soil texture (sand or slime) at each analysis plot location was also recorded. The highlights of this analysis are as follows. (Appendicies V & VI).

Treatment	Plants per square foot			
	Replicates	Sands	Slimes	Average
Coherex - mulch	3	.170	.311	.252
Coherex - no mulch	3	.067	.302	.128
Huels - mulch	2	.138	.748	.519
Soil Seal - mulch	3	.047	1.612	.647
Soil Seal - no mulch	3	.151	2.906	1.300
Kelgum - mulch	2	.092	1.797	.838
Kelzan 30# - mulch	1	.388	6.844	4.747
Kelzan 20# - mulch	1	.405	1.457	.855
Hydromulch 36	2	.127	1.530	1.110
Hydromulch 37	2	1.972	4.476	3.558
Hydromulch regular	1	1.205	6.356	5.326
Conwed blanket	1	5.969	24.105	22.593
American Excelsior blanket	1	--	4.744	4.744

As indicated by the pot tests conducted a year earlier, the slimes produced the most plants per square foot. The use of wood fiber mulch seemed to enhance vegetative development in combination with Coherex, yet had an opposite effect when used with Soil Seal. The best vegetative results from hydroseeding were achieved with regular Hydromulch only, followed by Kelzan at 30 pounds per acre with mulch and the experimental Hydromulch #37. The soil retention blankets provided the greatest amount of vegetative material of any of the materials tested.

Costs play a significant role in selecting any method for stabilization of mill tailings. Hydroseeding is considered as one of the least expensive, and in our case, was less expensive than the estimated costs of levelling, surfacing, and revegetation. Cost estimates for the experimental hydroseeding based upon bulk quantities delivered to the site and applied at the same concentrations as used are as follows:

Cost per Acre

Treatment	Stabilizer	Mulch	Hydroseeding	Total
Coherex, no mulch	$ 310.00	$ -0-	$ 162.00	$ 472.00
Coherex, Silva fiber	310.00	99.00	162.00	571.00
Coherex, Hydromulch	310.00	98.00	162.00	570.00
Huels, Silva fiber	160.00	99.00	162.00	421.00
Huels, Hydromulch	160.00	98.00	162.00	420.00
Soil Seal, no mulch	180.00	-0-	162.00	342.00
Soil Seal, Silva fiber	180.00	99.00	162.00	441.00
Soil Seal, Hydromulch	180.00	98.00	162.00	440.00
Kelgum, Silva fiber	32.50	99.00	162.00	293.00
Kelgum, Hydromulch	32.50	98.00	162.00	292.00
Kelzan20#, Silva fiber	33.00	99.00	162.00	294.00
Kelzan 30#, Silva fiber	49.50	99.00	162.00	310.50
Hydromulch	-0-	98.00	162.00	260.00
American Excelsior blanket	2130.00	N/A	N/A	2130.00
Conwed blanket	1940.00	N/A	N/A	1940.00

No cost figures are available for the experimental Conwed Hydromulches #36 and #37. The high cost Coherex reflects additional handling and storage facilities required for the large quantities of this material. Hydroseeding costs are an average of the total costs divided by acreage treated and do not reflect any time differences which may have resulted from problems associated with specific treatments. These costs do not include seed or fertilizer, which remained constant throughout the test.

The following items were noticed during the hydroseeding process:

1. Long fiber mulches are more difficult to apply through hoses than are short fiber mulches. This is especially true in conjunction with heavy stabilizing chemicals. In our case, the long fiber mulches ended up on the ground in grape sized balls while the short fiber material was more uniform. Nozzle pressures and time required for treatment were also adversely affected by the longer fiber mulches.

2. Chemicals and mulches are difficult to apply on dense slime surfaces. Even with the lowest nozzle pressures the material just slid along the surface as if it were ice and did not give uniform coverage.

3. Almost all stabilizing chemicals began to breakdown after the fourth month. Deer and other animals penetrated and permanently destroyed all maetrials except Coherex. Coherex seemed to reestablish its protective surface following the next rain.

4. Vegetative success is better on slimes than on sands. We believe this to be a result of the greater moisture content of the slimes plus its ability to hold moisture and nutrients at the interface with the sands.

5. Seed mixed with the mulch may cause problems. A lot of ungerminated seed was noticed in the mulch crusts. The ideal situation would be to apply the mulch after the seed.

The most recent inspection of the tailings pond was made the third week of April, 1973. Although the results were generally disappointing, several encouraging results were noted.

Natural vegetation immediately downwind from the pond, which in previous years had been sand blasted or buried, appeared relatively undisturbed. We're not sure whether this is a result of a wind free winter or our treatments. Although some areas showed evidence of new excavation by the wind, other areas remained relatively undisturbed. For the most part, no vegetation was seen in the hydroseed plots, except on the experimental Conwed plots and under the soil retention blankets. At this time, it would appear that the greatest vegetative success was the area treated with the excelsior soil retention blanket. We think now that the grasses and legumes were hidden beneath the one-inch thick mat and were not seen when the vegetative analysis was made.

Plots treated with Coherex retained the greatest amounts of crust and mulch surface. On some plots, up to 50% of the Coherex crust remains.

Our plans are to make a final evaluation of the experiment later in the summer, after the growing season has progressed sufficiently to determine how much vegetation survived or it sufficient delayed germination might occur. Should the seeding prove to be a total failure, then the final stabilization will be to level the dikes and surface with soil to achieve a natural, environmentally acceptable vegetative cover. We expect to accomplish this in the spring of 1974 at the latest.

Appendix I

Mouat Tailings Pond
Natural Vegetation

* Thick spike wheat grass	Agropyron dasystachyum
* Slender wheatgrass	A. trachycaulum
Bluebunch wheatgrass	A. spicatum
* Prairie sandreed	Calamovilfa longifolia
* Indian ricegrass	Oryzopsis hymenoides
* Sand dropseed	Sporobolus cryptandrus
* Canada wildrye	Elymus canadensis
Needle and thread	Stipa comata
Richarson needlegrass	S. Richardsonii
Sandberg bluegrass	Poa secunda
* Field sage (cudweed sagewort)	Artenesia ludoviciana
Big sage	A. tridentata
* Woods rose	Rosa woodsii
* 3 leaf (skunkbush) sumac	Rhus trilobata
* Raspberry	Rubus sp.
Ponderosa pine	Pinus ponderosa
* Limber pine	P. flexlis
* Douglas fir	Pseudosuga menzesii
* Cottonwood	Populus sp.
* Aspen	P. tremuloides
* Willow	Salix spp.
Others	

* In tailings material

Appendix II

Mouat Tailings Pond

Recorded Wind Velocities, MPH

Period	Average	Average Daily Date	Average Daily Speed	Highest Hour Date	Highest Hour Speed	Lowest Hour Date	Lowest Hour Speed
June 12-15	9.0	6/12	12.6	6/13	17	6/13,14	1 (1 hr)
June 16-30	7.9	6/23	12.0	6/23	18	6/20	0 (2 hrs)
July 1-15	6.7	7/13	11.1	7/13	19	7/4,15	0 (2 hrs)
July 16-31	7.5	7/22	11.4	7/22	23	7/18	0 (2 hrs)
August 1-15	7.1	8/13	10.9	8/1,14	16	8/7	0 (1 hr)
August 16-31	8.0	8/29	13.9	8/29	18	8/19	0 (1 hr)
Sept. 1-15	6.4	9/15	11.1	9/15	26	9/1	0 (3 hrs)
Sept. 16-30	12.6	9/30	26.3	9/16	34	9/25	0 (2 hrs)
Oct. 1-15	7.6	10/9	14.4	10/9	19	10/5,12,13,15	0 (1 hr)
Oct. 16-31	8.3	10/25	24/0	10/25	33	10/24	0 (5 hrs)
Nov. 1-15	9.8	11/2	19.6	11/2	26	11/11	0 (5 hrs)
Nov. 16-31	12.8	11/25	26/1	11/29	40	11/17	0 (2 hrs)
Dec. 1-15	19.5	12/15	29.2	12/13	46	12/3	2 (3 hrs)
Dec. 16-31	19.1	12/26	33.6	12/26	44	12/29	1 (2 hrs)
Jan. 1-15, 1973	14.7	1/12	26.9	1/1	42	1/8	0 (13 hrs)
Jan. 16-31	18.0	1/23	26.8	1/16,23,24	36	1/27	1 (2 hrs)
Feb. 1-15	11.5	2/1,2	23.5	2/2	36	2/8	0 (5 hrs)
Feb. 16-28	13.0	2/19	17.4	2/20	36	2/22	0 (2 hrs)
March 1-15	9.6	3/1	16/7	3/1	27	3/12	0 (5 hrs)
March 16-31	7.6	3/26	13.0	3/26	21	3/23	0 (4 hrs)
April 1-15	9.1	4/4	14.6	4/9	23	4/1	0 (2 hrs)

Appendix III

Mouat Tailings Pond

Hydroseeding Application Rates

Stabilizing chemical	Quantity	Water	Wood Fiber Mulch Brand	Wood Fiber Mulch Quantity	No. 1 Acre Plots
Coherex	750 gals (1:4)	3000 gals	Weyerhaeuser	1400 lbs	2
Coherex	750 gals (1:4)	3000 gals	Conwed	1500 lbs	1
Coherex	750 gals (1:4)	3000 gals	none		3
Soil Seal	50 gals	1750 gals	Conwed	1500 lbs	1
Soil Seal	50 gals	1750 gals	Weyerhaeuser	1400 lbs	2
Soil Seal	50 gals	1750 gals	none		3
Huels S.S. 801	40 kg	3000 gals	Weyerhaeuser	1400 lbs	1
Huels S.S. 801	40 kg	3000 gals	Conwed	1500 lbs	1
Kelgum	25 lbs	2500 gals	Weyerhaeuser	1400 lbs	1
Kelgum	25 lbs	2500 gals	Conwed	1500 lbs	1
Kelzan	20 lbs	2500 gals	Weyerhaeuser	1400 lbs	1
Kelzan	30 lbs	2500 gals	Weyerhaeuser	1400 lbs	1
None		3000 gals	Conwed #36	1500 lbs	1.5
None		3000 gals	Conwed #37	1500 lbs	1.5
None		3000 gals	Conwed regular	1500 lbs	.5

Appendix IV

Mouat Tailings Pond

Seed Mixture for Hydroseeding Trail

Pubescent Wheat Grass (Agropyron tracheophyllum)	1.9#/acre
Bulbous Bluegrass (Poa bulbosa)	.5#/acre
Indian Ricegrass (Oryzopsis hymenoides)	2.5#/acre
Intermediate Wheatgrass (Agropyron intermedium)	4.9#/acre
Hard Fescue (Festuca ovina var. Durar)	2.8#/acre
Prairie Sandreed (Calamovilfia longifolia)	2.0#/acre
Mammouth Wildrye (Elymus giganteus)	.3#/acre
Kentucky Bluegrass (Poa pratensis)	1.8#/acre
Yellowsweet Clover (Melilotus officinalis)	.5#/acre
White Dutch Clover (Trifolium repens var.)	2.3#/acre
Alsike Clover (Trifolium hydridum)	.5#/acre
TOTAL	20.0#/acre

Appendix V

Mouat Tailings Pond

Experimental Hydroseeding Plant Density

Treatment*	Plot No.	Sand plants/ft^2	Slimes plants/ft^2	Average plants/ft^2
Coherex, W	1	.164	.169	.166
Coherex, W	13	0	.053	.052
Coherex, C	8	.180	1.530	.585
Coherex, N	18	.015	0	.015
Coherex, N	15	.006	0	.006
Coherex, N	19	.052	0	.052
Coherex, M	-	.170	.311	.252
Coherex, N	-	.023	0	.023
Soil Seal, C	3	.166	.230	.201
Soil Seal, W	7	.014	2.879	1.733
Soil Seal, W	10	.006	0	.006
Soil Seal, N	11	.023	0	.023
Soil Seal, N	17	.055	1.716	.816
Soil Seal, N	21	.944	3.636	3.030
Soil Seal, M	-	.047	1.612	.647
Soil Seal, N	-	.151	2.906	1.300
Huels S.S. 801, W	2	.344	.107	.166
Huels S.S. 801, C	12	.034	1.710	.872
Huels S.S. 801, M	-	.138	.748	.519

* KEY: W = Weyerhaeuser "Silva fiber" mulch

C = Conwed "Hydromulch"

N = No mulch

M = All mulch treatments

Appendix V
(continued)

Treatment*	Plot No.	Sand plants/ft^2	Slimes plants/ft^2	Average plants/ft^2
Kelgum, W	5	.027	1.537	.895
Kelgum, C	9	.131	2.296	.780
Kelgum, M	-	.092	1.797	.838
Kelzan 30#,W	6	.388	6.844	4.746
Kelzan 20#,W	14	.405	1.457	.855
Kelzan, W	-	.170	4.360	2.793
		.153		
Hydromulch 36	4	.689	.376	.241
Hydromulch 36	22B		3.228	2.847
		.127		
Hydromulch 36	-		1.530	1.110
Hydromulch 37	16	.062	2.834	2.072
Hydromulch 37	22B	3.882	9.769	6.531
Hydromulch 37	-	1.972	4.476	3.558
Hydromulch regular	23A	1.205	6.356	5.326
American Excelsior blanket		0	4.744	4.744
Conwed blanket		5.969	24.105	22.593
All mulch		.280	2.169	1.337
No mulch		.071	2.794	.689
Blanket		5.969	14.004	13.669

* KEY: W = Weyerhaeuser "Silva fiber" mulch

C = Conwed "Hydromulch"

N = No mulch

M = All mulch treatments

Appendix VI

Mouat Tailings Pond

Experimental Hydroseeding Plant & Soil Distribution

Treatment*	Plot No.	Soil Texture % Sand	Soil Texture % Slimes	Vegetated (%) Sand	Vegetated (%) Slimes	% Slimes of Total Vegetation
Coherex, W	1	52.5	47.5	14.3	47.4	33.3
Coherex, W	13	2.5	97.5	0	12.8	100.0
Coherex, C	8	70.0	30.0	21.4	75.0	60.0
Coherex, N	18	100.0	0	5.0	0	0
Coherex, N	15	95.0	5.0	2.6	0	0
Coherex, N	19	100.0	0	22.5	0	0
Coherex, M	-	41.7	58.3	18.0	32.8	71.9
Coherex, N	-	88.3	11.7	11.3	0	0
Soil Seal, C	3	45.0	55.0	5.6	13.6	75.0
Soil Seal, W	7	40.0	60.0	6.2	100.0	96.0
Soil Seal, W	10	100.0	0	0	2.5	0
Soil Seal, N	11	100.0	0	7.5	0	0
Soil Seal, N	17	42.5	47.5	9.5	57.9	84.6
Soil Seal, N	21	22.5	77.5	80.0	83.9	86.7
Soil Seal, M	-	61.7	38.3	4.0	58.7	90.0
Soil Seal, N	-	58.3	41.7	12.8	74.0	80.4
Huels S.S. 801, W	2	25.0	75.0	30.0	66.7	86.9
Huels S.S. 801, C	12	50.0	50.0	15.0	50.0	84.6
Huels S.S. 801, M	-	37.5	62.5	20.0	60.0	83.3

* KEY: W = Weyerhaeuser "Silva fiber" mulch

C = Conwed "Hydromulch"

N = No mulch

M = All mulch treatments

Appendix VI
(continued)

Treatment*	Plot No.	Soil Texture % Sand	Soil Texture % Slimes	Vegetated (%) Sand	Vegetated (%) Slimes	% Slimes of Total Vegetation
Kelgum, W	5	42.5	57.5	11.8	65.2	88.2
Kelgum, C	9	70.0	30.0	25.0	75.0	56.0
Kelgum, M	-	56.2	43.8	20.0	69.6	72.7
Kelzan 30#, W	6	32.5	67.5	38.5	81.5	81.5
Kelzan 20#, W	14	42.5	57.5	11.8	69.6	88.9
Kelzan, W	-	37.5	58.8	30.4	80.8	84.4
Hydromulch 36	4	37.5	62.5	6.7	48.0	92.3
Hydromulch 36	22B	15.0	85.0	66.7	82.4	87.5
Hydromulch 36	-	30.0	70.0	16.7	61.9	89.6
Hydromulch 37	16	27.5	72.5	27.3	86.2	89.3
Hydromulch 37	22A	55.0	45.0	36.4	88.9	66.7
Hydromulch 37	-	36.7	63.3	31.8	86.8	82.5
Hydromulch regular	23A	20.0	80.0	100.0	100.0	80.0
American Excelsior blanket		0	100.0	0	100.0	100.0
Conwed blanket		8.3	91.7	100.0	100.0	91.7
All mulch		44.0	56.0	18.6	62.5	81.9
No mulch		78.3	21.7	11.2	71.2	63.8
Blanket		4.2	95.8	100.0	100.0	95.8

* KEY: W = Weyerhaeuser "Silva fiber" mulch

C = Conwed "Hydromulch"

N = No mulch

M = All mulch treatments

Appendix VII

Mouat Tailings Pond

Chemical & Physical Properties

A. Chemical Properties (sampled prior to treatment)

Sample	pH	E Ce mmhos/cm	Cu	Ni	Cr	Fe	Zn	Pb	NO_3	K	P
Dike Sand	9.7	94	0.2	2.0	0.1	4.3	0.3	ND	3	18.5	1.3
Dune Sand	9.9	96	0.7	2.8	ND	2.2	0.2	ND	12	20.0	1.3
Slimes	8.8	214	0.4	1.2	ND	ND	ND	ND	25	30	0.6

B. Mineralogical Analysis (%)

Sample	Feldspar	Quartz	Amphibole	Olivine	Sericite	Biotite	Carbonates	Montmorillonite	Chlorite	Talc	Serpentine	Gypsum	Epidote	Apatite	Fe Oxides	Pyrite	Pyrrhotite	Chalcopyrite
Dike Sand	Tr	Tr	4.0	50.0	Tr	Tr	Tr	3.0	7.0	9.0	16.0	ND	ND	ND	9.0	Tr	ND	Tr
Dune Sand	Tr	Tr	5.0	35.0	Tr	ND	2.0	5.0	6.0	12.0	22.0	ND	ND	ND	10.0	Tr	ND	Tr
Slime	Tr	Tr	2.0	25.0	Tr	Tr	4.0	2.0	8.0	16.0	25.0	ND	ND	ND	15.0	Tr	ND	Tr

C. Particle Size Distribution (Tyler Screen) %

Screen Size

Sample	4	10	20	50	80	100	200	-200
Dike Sand	<.1	<.1	3.7	46.4	28.7	5.6	12.2	3.4
Dune Sand	NF	NF	<.1	41.3	35.2	5.5	14.7	3.3
Slimes	<.1	<.1	2.3	8.3	3.6	1.0	10.2	74.2

D. % Moisture at Field Capacity

Dike Sand	23.0%
Dune Sand	24.5%
Slimes	35.3%

Appendix VIII

Mouat Tailings Pond

Test Material Suppliers

A. Stabilizing Chemicals

1. Coherex	Golden Bear Division Witco Chemicals Box 378 Bakersfield, California 93302
2. Soil Seal	Soil Seal Corporation 6311 Rutland Avenue Riverside, California 92503
3. Huels Soil Stabilizer 801	Henley & Company, Inc. 202 E. 44th Street New York, New York 10017
4. Kelgum, Kelzan	Kelco Company 75 Terminal Avenue Clark, New Jersey 07066

B. Wood fiber mulches

1. Silva fiber	Weyerhaeuser Company Tacoma, Washington 98401
2. Hydromulch, Soil retention blanket	Conwed Corporation 2200 Highcrest Road St. Paul, Minnesota 55113

C. Soil Retention blanket

1. American Excelsior	American Excelsior Company Box 5067 Arlington, Texas 76011

D. Others

Seed Supply, Consulting	Soil Conservation Service U.S. Dept. of Agriculture Box 970 Bozeman, Montana, 59715
Hydroseeding	Environmental Erosion Control Division of Toro Sales Company 906 4th Street, NW Puyallup, Washington 98371

THE ANACONDA Co.
MOUAT TAILINGS POND
NYE, MONTANA
EXPERIMENTAL DUST CONTROL PLOTS

Scale
100 Ft.
May, 1972
North